MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER PROGRAM (STTR)

INTRODUCTION

The MDA STTR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). The MDA STTR Program Manager is Frank Rucky. If you have any questions regarding the administration of the MDA STTR program please call 1-800-WIN-BMDO. Additional information on the MDA STTR Program can be found on the MDA STTR home page at http://www.winbmdo.com/. Information regarding the MDA mission and programs can be found at http://www.acq.osd.mil/bmdo.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457. For technical questions about the topic, contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **3 March 2003.**

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $70,000.

Phase I Proposal Submission

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. MDA accepts Phase I proposals not exceeding $70,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, **ENTIRE** Technical Proposal with any appendices, Cost Proposal, and the Company Commercialization Report -- be submitted electronically through the DoD STTR website at http://www.dodsbir.net/submission. Each of these documents is to be submitted separately through the website. Your complete proposal **must** be submitted via the submissions site on or before the **5:00pm EST, 16 April 2003 deadline.** A hardcopy **will not** be required. If you have any questions or problems with electronic submission, contact the DoD SBIR Help Desk at 1-866-724-7457 (8am to 5pm EST).

PHASE II GUIDELINES

Phase II is the demonstration of the technology that was found feasible in Phase I. MDA selects awardees for Phase II developments through two competitive processes: a routine competition among Phase I awardees that have been invited to submit Phase II proposals; and a Fast Track competition for Phase I awardees that are able to successfully obtain third party cash partnership funds.

The MDA STTR Program Manager (PM) or one of MDA's executing agents for STTR contracts will inform Phase I participants of their invitation to submit a Phase II proposal. Fast Track submissions do not require an invitation; see DoD's Fast Track guidelines. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA STTR website http://www.winbmdo.com/ for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline. MDA may also require a hardcopy or your proposal.

MDA FASTTRACK Dates and Requirements:

The Fast Track application must be received by MDA 150 days from the Phase I award start date. Your Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the MDA STTR Program Manager, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Execution Activity STTR Program Manager. The information required by MDA, is the same as the information required under the DoD Fast Track described in the front part of this solicitation.

STTR Phase II Enhancement Policy

To encourage the transition of STTR research into MDA acquisition programs, MDA has implemented a Phase II Enhancement Policy. Under this policy, MDA can allow extension of an existing Phase II contract for up to one year and can provide additional Phase II funding of up to $250,000, either: 1) as matching funds for non-STTR MDA funds directed to the Phase II contract; or 2) as transitional funding in anticipation of Phase III, based on a letter of intent to the MDA STTR PM from a MDA acquisition program that will award a Phase III contract.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your technical proposal has been uploaded. The DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and the Cost Proposal have been submitted electronically through the DoD submission site by 16 April 2003.

____2. The Phase I proposed cost does not exceed $70,000.

MDA 2003 STTR TOPICS

MDA03T-001	Data Driven Prognostics
MDA03T-002	Infrared materials modeling for next generation focal plane architectures
MDA03T-003	Develop and/or Improve Optical Coating Processes for Military Mirrors
MDA03T-004	Advanced Chemical Iodine Lasers
MDA03T-005	Thermal Decomposer for Peroxide
MDA03T-006	Ultra Tight Coupling for High Anti-Jam GPS/INS

MDA 2003 STTR TOPIC DESCRIPTIONS

MDA03T-001 TITLE: Data Driven Prognostics

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/AL

OBJECTIVE: Develop a data driven prognostic system that provides advanced warning of failure, fault, and other error events.

DESCRIPTION: Computer-controlled equipment continually generates operating data, such as sensor logs, command logs, activity logs and error code logs, that act as a record of their operating history. Such data can be represented mathematically to describe the state of a machine at a point in time. A functioning system creates a dataset in n-dimensional space containing certain, recognizable signatures, whilst a malfunctioning system generates different data and creates different signature sets with each signature being specific to a particular condition or event. These signatures are separated by complex partitions in the n-dimensional dataset.

The objective of the project is to develop and demonstrate a library of predictive algorithms based on a number of advanced pattern recognition techniques - such as multivariate statistics, genetic algorithms, neural networks, signal analysis and mathematical logic - which identify the partitions that separate the early signatures of functioning systems from those later signatures of malfunctioning systems, thereby allowing the prediction of specific machine or system malfunctioning events prior to their occurrence.

The development of the predictive algorithms is to be general, that is, the library should be able to be ported to different systems and environments. However, to test and prove the efficacy of various approaches, the library should be developed for a specific part of the Airborne Laser program, such as the laser system or the beam tracking and control system. The Airborne Laser (ABL) is interested in developing technology that will enable better health monitoring and life prediction for critical components. A prognostic system that is able to provide an accurate picture of faults, component degradation, and predictive indicators of failures will be extremely useful, allowing our operators to take preventive maintenance actions to avoid costly or catastrophic damage on critical parts and to maintain availability/readiness rates for the system.

PHASE I: This initial phase will involve defining target events for prediction. A specific component or subsystem of the ABL program will be identified, and a preliminary prediction should be performed for that component or subsystem. An outline of the predictive algorithm library should be developed.

PHASE II: This phase will involve developing the predictive algorithms in the library, implementing them in software, and testing them against actual system failures or system events. The ABL is willing to allow the contractor to model one or more components or subsystems as part of Phase II. The goal of this phase should be a demonstration of the predictive failure library in a test field environment. The algorithms should be evaluated on their capability to recognize various target events, and should be measured on accuracy (false positive/false negative) and on lead-time provided (how far in advance does the algorithm correctly classify a set of data into a "bad" partition indicating a failure state?). This phase should include the development of an architecture (in addition to the library of algorithms) that provides an automated solution for data collection, data integration, transformation, prediction, and display of prognostic results at a fleet level (e.g., perform the failure predictions on multiple systems).

PHASE III: Phase III will involve a commercialization of this predictive library into a prognostic system that can be deployed across other systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The ability to predict machine/equipment events has significant commercial potential in aircraft, power, manufacturing, processing, transportation, and other industrial applications where such capability would allow companies to improve reliability and safety, reduce downtime, and lower the direct maintenance cost of physical assets.

REFERENCES:
(1) Artificial Intelligence in Equipment Maintenance and Support: Papers from the 1999 AAAI Spring Symposium, Technical Report SS-99-04, ISBN 1-57735-081-2.

(2) 2001 IEEE Aerospace Conference Proceedings. Track 11: Diagnostics, Prognostics, and Health Management. IEEE Catalog Numbe 01TH8542C, ISBN 0-7803-6600-X.

(3) Soft Computing Techniques for Diagnostics and Prognostics, P. Bonissone and K. Goebel, GE CR&D, from (1).

(4) Fault Prognosis Using Dynamic Wavelet Neural Networks, P. Wang and G. Vachtsevanos, Georgia Tech (1).

(5) Prognostics, The Real Issues Involved with Predicting Life Remaining, S. Engel, B. Gilmartin, K. Bongort, and A. Hess, Northrup Grumman, 2000 IEEE Aerospace Conference Proceedings, ISBN 0-7803-5846-5.

KEYWORDS: Failure prediction, prognostics, health management

MDA03T-002 TITLE: Infrared materials modeling for next generation focal plane architectures

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: MDA/GM

Objective: Develop models for Infrared (IR) material growth structures in order to understand material processes for the fabrication of integrated monolithic multicolor HgCdTe IR Focal Plane Arrays (IRFPAs). Models should address combinations of material from MWIR (3-6.5 ƒÝm) up to VLWIR (>14 ƒÝm) in two to as many as four layers.

Description: Currently materials process modeling is done for single-color IRFPAs. The next generation of IRFPAs for use in missile defense systems (such as GMD and THAAD) will probably be integrated monolithic multicolor devices. Modeling of these multicolor devices is critical to efficiently prototype new process designs. This effort seeks to establish mathematical modeling and numerical simulation for the design and control of advanced material processing systems for next-generation HgCdTe IRFPAs. Significant modeling challenges include deposition, defect elimination, and control of the processes. Models are expected to enable design and fabrication of functional integrated monolithic multicolor HgCdTe IRFPAs.

Phase I: Develop the concept for a modeling/simulation tool that can be used to predict material properties and process characteristics, and support design of structures for integrated monolithic multicolor HgCdTe IR detectors. Conduct feasibility demonstrations to show that the tool can be successfully developed. E.g., identify critical features and design/develop software elements demonstrating these features.

Phase II: Develop the model/tool. Calibrate and validate/verify the model with measurements on experimental devices. Design, fabricate, and test a scalable integrated monolithic multicolor HgCdTe IRFPA as one of the experimental devices.

Phase III: Demonstrate (design, fabricate, and test) a working prototype next-generation integrated monolithic multicolor IRFPA, as facilitated by the model. The prototype shall be compatible with requirements of missile defense systems (such as GMD and THAAD), and if not meeting operational requirements directly, shall show a clear path to fulfilling requirements to transition to the BMD system developers.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Multicolor IR sensors would contribute to weather science, material science, metrology, industrial process monitoring, and surveillance. In particular, monolithic multicolor FPA enables simpler, more capable and less costly sensors for measuring temperature and emissivity of materials.

REFERENCES:

1. H.Robinson, Process Modeling of HgCdTe Infrared Photdetectors, Proceedings of the 1997 U.S.Workshop on Physics and Chemistry of II-VI materials.

2. H.R. Vydyanath, V. Nathan, L. Becker and G. Chambers , Invited paper 'Materials and process issues for high performance HgCdTe infrared detector fabrication' SPIE, 3629, 81(1999)

3. H.R. Vydyanath and V. Nathan, Invited Paper 'Materials and process issues of high performance VLWIR HgCdTe infrared detectors' Opto-Electronics Review 9, 1 (2001)

4. A. Rogaski, 'Comparison of performance limits of Infrared detector material' SPIE, 4650, 117(2002)

KEYWORDS: modeling; multicolor; IRFPA; material growth; MCT; infrared

MDA03T-003 TITLE: <u>Develop and/or Improve Optical Coating Processes for Military Mirrors</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: MDA/GM

OBJECTIVE: Identify, develop, and demonstrate improvements in optical coating processes that can be employed by industry to achieve reliable, repeatable, affordable optical coatings that consistently meet performance standards necessary for military applications.

DESCRIPTION: Major suppliers of Beryllium (Be)/Beryllium alloy (Be alloy) military mirrors require optical coatings that are free of anomalies. Anomalies such as delamination and discoloration require costly, and sometimes damaging, remediation. An understanding of optimal, affordable coating processes for a variety of Be/Be alloy military mirror applications is required to eliminate or reduce the frequency of occurrence of anomalies that can adversely impact cost and schedule.

Phase I: Determine/define optimal coating processes for Be/Be alloy optic components that are both reliable and repeatable, identifying any available expertise. Identify and define the equipment necessary to perform coating processes on Be/Be alloy components to include a ROM funding requirement. Determine a viable solution path to resolve current problems.

Phase II: Successful completion of Phase I would lead to an actual prototyping effort, either full scale or to scale, to verify process viability and demonstrate performance. An existing military mirror program with known material (e.g., Be or Be alloy) and performance requirements will be selected prior to Phase II initiation. In addition to the prototype effort, a fully documented reliable/repeatable optical coating process that could be integrated in a vendor's facility will be required.

Phase III: Successful completion of Phase II will result in a fully documented reliable, repeatable, validated optical coating process that can be implemented by the component supplier or by any member of the coating house industrial base interested in supporting military applications.

PRIVATE SECTOR COMMERICAL POTENTIAL: Few commercial opportunities are known for flat optics coating but it is assumed that some potential exists in commercial satellite applications. Military aviation programs utilize Be/Be alloy mirrors with optical coatings and commercial opportunities may exist for non-military counterparts. Additionally, military mirror applications cross multi-agency lines including but not limited to the Army Force, Army, Navy and Missile Defense Agency. These can be a part of track and acquisition sensors, scan mirrors, and optical bench assemblies.

REFERENCES:
1. Martin, P.M., et al. 1989. "Microwave and Laser Rejection Coatings for Optical Windows". Proceedings of the Seventh DoD Conference on DEW Vulnerability, Survivability, and Effects, Monterey, CA May 8-12.
2. Pawlewicz, W.T., et al. 1986. "Multilayer optical coating fabrication by dc magnetron reactive sputtering." SPIE Vol 678 Optical Thin Films II: New Developments, pp 134-140.
3. Pawlewicz, W.T., et al. 1984. "1315 NM Dielectric Mirror Fabrication by Reactive Sputtering," Proceedings of the Topical Meeting on High Power Laser Optical Components, Boulder, CO, Oct 18-19.
4. Willey, Ronald R. 1986. "Survey of the State of the Art of Automation of Optical Coaters". Proceedings of Society of Vacuum Coaters, 29, pp 262-274.
5. Thonini, W.P., 1982. "Deposition of Optical Coatings: Process Control and Automation". Thin Solid Films, 88, pp 385-397.
6. Willey, Ronald R. 1987. " Optical thickness monitoring sensitivity improvement using graphical methods." Applied Optics, 26, 4, pp 729-737.
7. Zoller, A., Herrmann, R., Klug, W., and Zultzke, W. 1986. "Optical Monitoring: Comparison of Different Monitoring Strategies with Respect to the Resulting Reproducibility to the Completed Layer Systems". Proceedings Society Photo-Optical Instrumentation, England, 652, 21.
8. Guenther, Karl H., Fellows, Charles W., and Willey, Ronald 1988. "Reactive Ion Plating – A Novel Deposition Technique for Improved Optical Coatings." Proceedings of Society of Vacuum Coaters, 31, pp 186-191.
9. Willey, Ronald R. 1992. "New point of view on the synthesis of thin films using Fourier transforms." SPIE Vol 1782, pp 133-144.
10. Willey, Ronald R. 1993. "Achieving improved optical thin film control and uniformity of silicon dioxide by using ion assisted deposition." Proceedings of Society of Vacuum Coaters, 36, pp 75-78.
11. Willey, Ronald R. 1994. "Some comparisons in the application of End-Hall and Cold Cathode ion sources in the conversion of SiO to SiO2." SPIE, Vol 2262, pp 14-21.
12. Willey, Ronald R. 1996. "Estimating the number of layers required and other properties of blocker and dichroic optical thin films". Applied Optics, Vol. 35, pp 4982-4986.
13. Willey, Ronald R. 1999. "Methods to reduce optical coating and other process development time and cost while increasing process stability." The 11th International Meeting on Elector-Optics in Israel, Tel Aviv.
14. Willey, Ronald R. 2000. "Design of Optical Coatings Taking Consideration of Probable Production Errors." Proceedings of Society of Vacuum Coaters, 43, pp 230-233.

KEYWORDS: Vapor Deposition, Sputter Coating Deposition, Plasma Coating Deposition, Polymer Multilayer (PML) technology, Liquid Multilayer (LML) technology, Plasma Polymer Multilayer (PPML) technology, electron-beam deposition, visible and infrared optical coatings, optical thin film coating processes, conformal coatings, sensors, flat metal optics, military mirror applications, precision machined optical components, deposition systems, ion beam sputtering, 6 Sigma, process monitoring and control.

MDA03T-004 TITLE: Advanced Chemical Iodine Lasers

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: MDA/SL

OBJECTIVE: Demonstrate innovative concepts relevant to the development of a high-energy chemical iodine laser.

DESCRIPTION: MDA is interested in promoting and conducting innovative research on promising new technologies relevant to the development of high-energy chemical iodine lasers. The most common chemical iodine laser, COIL (Chemical Oxygen Iodine Laser), uses the highly efficient reaction between molecular chlorine and basic hydrogen peroxide (BHP) to generate electronically excited (singlet delta) oxygen. Singlet delta oxygen reacts via electronic energy transfer with atomic iodine to produce a population inversion on the I*(2P1/2) - I(2P3/2) spin-orbit transition. Provided that sufficient gain can be achieved, single line lasing at 1.3 microns is the result of the energy transfer process. Similarly, the All Gas-phase Iodine Laser (AGIL) produces electronically NCl that also reacts with atomic iodine to produce a population inversion.

Unfortunately, traditional COIL devices require the use of highly corrosive and bulky liquid reagents (eg. BHP) and current AGIL concepts use hydrogen azide (HN3) a highly toxic and explosive gas. These features are troublesome for both airborne and space-based applications and the directed energy community is seeking alternative methods for generating singlet delta oxygen and/or NCl.

Potential sources of electronically excited O2 and NCl include electric discharges, alternative chemical mechanisms, optical pumping schemes, or other efficient energy transfer processes. Proposed concepts must be capable of producing high number densities of singlet delta O2, NCl, or another acceptable energy carrier.

Phase I: 1) Define and model a promising chemical iodine laser concept or energy carrier generator. Or 2) investigate issues related to the production, storage, and usage of high densities of hydrogen azide or an alternative source of singlet delta NCl. Identify and investigate the key physical or chemical processes and arrive at a design concept.

Phase II: Continue the effort initiated in Phase I. Design, construct, and carry out the key experiment(s) identified in Phase I. Generate an engineering design for a full-scale device. Where appropriate, construct and demonstrate the full-scale device.

Phase III: Construct full-scale lasers appropriate for use by industries interested in applying high-energy lasers for use in machining and manufacturing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Possible applications include nuclear reactor decommissioning, robotic welding, and mining / drilling.

REFERENCES:
1. Gerald C. Manke II and Gordon D. Hager, "Advanced COIL - Physics, Chemistry, and Uses," J. Mod. Opt., accepted, 2001.
2. Thomas L. Henshaw, Gerald C. Manke II, Timothy J. Madden, Michael R. Berman, and Gordon D. Hager, "A New Energy Transfer Laser at 1.315 microns," Chem. Phys. Lett., Vol. 325, pp. 537- 544, 2000.

KEYWORDS: Chemical lasers; Directed energy weapons; Lasers; Space based lasers; Airborne lasers; COIL; AGIL.

MDA03T-005 TITLE: <u>Thermal Decomposer for Peroxide</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: MDA/TC

OBJECTIVE: Demonstrate cost effective techniques for non-catalytic decomposition of hydrogen peroxide in high concentrations.

DESCRIPTION: As rocket propellant, Hydrogen Peroxide must be used in high concentration, also known as High Test Peroxide (HTP). HTP is passed over a catalyst bed to decompose it prior to entering the main combustion chamber. Additives are minimized to prevent fouling of the catalyst bed; yet stabilizers and inhibitors are necessary to lower the hazards and costs of operating with HTP, which is unstable and highly oxidizing. Stabilizers prevent explosive decomposition of the material; and corrosion inhibitors provide for a longer storage life. MDA seeks alternative techniques for decomposing HTP so that a more stable and storable form of the oxidizer can be used in liquid-fuel systems. Examples are the Liquid Fuel Booster System and the power source for chemical lasers. The only other documented decomposition mechanism is thermal; yet past attempts at employing thermal decomposers frequently resulted in catastrophic failure. The mechanisms accounting for catastrophic HTP thermal explosive decomposition are not understood. This topic has three objectives, which correspond to the project phases: 1) understand the factors governing thermal decomposition of peroxide; 2) develop a controllable thermal decomposer; 3) demonstrate the thermal decomposer in a representative component.

Phase I: Develop a model predicting and explaining thermal decomposition of hydrogen peroxide. A mechanistic model is acceptable that captures the fundamental physics of peroxide behavior. The model should indicate an effective method of controlling thermal decomposition. Perform feasibility analysis for applying the method with fuel concentrations of H202, including the safety and reliability of the method in comparison with previous approaches to thermal decomposition. Define enabling technologies for testing the recommended method.

Phase II: Create and test a laboratory scale device for thermally decomposing peroxide in a controlled manner, using the technologies identified in Phase I. Test the device to verify the effects of the physics represented in the model developed in Phase I, which should include predictable response over a wide range of flow conditions and flow transients. Perform analysis and tests to demonstrate the scalability of the technique to quantities and concentrations of H202 that would be needed as a rocket motor propellant. Produce a conceptual design for a prototype decomposer consistent with the space and environmental constraints of a booster system such as the MDA Liquid Fuel Booster System.

Phase III: Develop a thermal decomposer with characteristics appropriate for having it qualified for operation within a booster system. Demonstrate the performance of the decomposer with a wide range of stabilizers and over a range of HTP qualities selected in consultation with the sponsor. Based on the performance of the prototype decomposer, perform analysis to compare the life cycle performance and cost of the thermal system with catalytic decomposition systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Non-catalytic decomposition will allow new and wider use of HTP for commercial as well as military applications. The lower operating costs from use of stabilized and corrosion-inhibited HTP will allow the private sector to apply HTP to the full range of systems requiring liquid-based fuels. Examples include electric power generation, flight engines, and space launch vehicles.

REFERENCES:
1) 2nd GRLV TA-6, Upper Stage, Chamber and Nozzle Risk Reduction, Hydrogen Peroxide Detonation Studies, Williams Watkins, Steven Zeppleri, Lou Spadaccini, Mindy Roeder, Pratt & Whitney, NASA MSFC, NAS8-0118

2) Advancements in High Concentration Hydrogen Peroxide Catalyst Beds, M. Ventura and E. Wernimont, AIAA Paper # AIAA-01-3250, July, 2001.

3) Performance Calculations of Hydrogen Peroxide as a Monopropellant, Part II Heterogeneous Systems, Brinkley, Smith and Edwards, Bureau of Mines, Report PX3-107/14, June 1953.

4) Hydrogen peroxide engines - Early work on thermal ignition at Westcott, Harlow, John, International Hydrogen Peroxide Propulsion Conference, 2nd, Purdue University, West Lafayette, IN, Nov. 7-10, 1999 (A01-39476 10-28)

5) Thermal decomposition of hydrogen peroxide vapor at elevated temperatures behind incident and reflected, BILWAKESH, K R, Ohio State Univ., Columbus, PH.D. THESIS, 1969, Accession Number, N71-29624

KEYWORDS: Hydrogen Peroxide; thermal decomposition; peroxide decomposition; propellant; liquid fuel; rocket motors

MDA03T-006 TITLE: Ultra Tight Coupling for High Anti-Jam GPS/INS

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: MDA/AS

OBJECTIVE: Develop new advanced processing techniques for GPS/INS in the area of Ultra Tight Coupling between the GPS receiver tracking functions and the IMU and navigation functions. The improved processing should result in substantial improvements in capability and tracking loop tolerance to vehicle dynamics for a wide range of surface launched weapons utilizing GPS/INS. The more robust processing should render these weapons much more effective in hostile environments.

DESCRIPTION: A major trend in the evolution of surface launched weapons is the use of miniature, low cost, high anti-jam GPS subsystems. A wide range of weapon systems in various stages of development rely on GPS integrated with an inertial navigation system (GPS/INS) to provide accurate in-flight navigation and guidance to designated targets. A common factor for all these GPS-equipped weapons is an operational environment in which jamming is expected. A new technology innovation in the use of GPS/INS is showing considerable promise in mitigating or defeating the jamming threat:

New developments in Ultra Tightly Coupled GPS/INS integration architectures offer the possibility of substantial improvements in jamming immunity. Traditional GPS/INS designs use a tightly coupled architecture in which the GPS receiver internally tracks the broadcast signal and constructs the estimated range and range rate (pseudo-range & delta-range) to the satellites. A GPS/INS navigation filter is placed downstream of this to blend the GPS and inertial measurements and obtain the vehicle navigation solution. This architectire is sub-optimal from the standpoint of preventing signal loss due to jamming, and also allows the possibility of loosing GPS lock due to high vehicle dynamic conditions.

The Ultra Tightly Coupled architecture combines the receiver signal tracking and navigation filter functions into a single integrated design. In this case, the filter operates on the receiver track loop I and Q signals which are at a more basic level than the pseudo-range and delta-range. This approach permits a higher level of jamming and also prevents GPS loss-of-lock in high dynamic environments. The Ultra Tight Coupling technology can provide a robust GPS anti-jam system, which permits the weapon system to operate effectively.

PHASE I: Demonstrate a preliminary integrated navigation system design for Ultra Tightly Coupled GPS/INS using generic missile and target models to be provided. Demonstrate by simulation that the design technique provides significant anti-jam immunity and robustness to vehicle dynamics.

PHASE II: Evaluate alternative Ultra Tightly Coupled GPS/INS design architectures. Assess the performance of each and down select a chosen design. Fully exercise the selected integrated design for the selected missile over a broad engagement space. If possible, perform laboratory testing of an Ultra Tightly Coupled GPS/INS design using actual GPS receiver hardware and jamming simulator.

PHASE III: Transition research to missile system designer(s). Participate with development contractor(s) in performing hardware-in-the-loop testing of an integrated and Ultra Tightly GPS/INS design, and in verifying performance of the design via demonstration flight testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Besides the obvious military aerospace role, integrated GPS/INS design methods have direct applications in the areas of civilian aviation, autonomous vehicles, maritime systems, ground transportation, surveying, remote sensing, precision surveillance and targeting and others. Algorithms and methods developed under this STTR will be useful in a wide range of military and commercial systems.

REFERENCES:

1. Schmidt, G. T., “GPS/INS Technology Trends for Military Systems,” Paper # 97-3826, AIAA Guidance, Navigation & Control Conference, New Orleans, LA, Aug 11-13, 1997.

2. Phillips, R. E. and Schmidt, G. T., “GPS/INS Integration,” NATO AGARD Lecture Series on System Implications and Innovative Applications of Satellite Navigation, LS-207, Paris, France, July 1996.

3. Kreye, C., et al., “Improvements of GNSS Receiver Performance Using Deeply Coupled INS Measurements,” ION GPS 2000, Salt Lake City, UT, 19-22 Sept, 2000.

4. Gustafson, D., Dowdle, J., and Flueckiger, K., “A High Anti-Jam GPS-Based Navigator,” Proc. ION 2000, Annual Technical Meeting, Anaheim, CA, Jan 2000.

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6. Parkinson, Bradford W., Spilker, James J., Axelrad, Penina, Enge, Per, Global Positioning System: Theory and Applications", Vols. I and II, American Institute of Aeronautics and Astronautics, Washington DC, 1995.

7. Kaplan, Elliott D., Ed., Understanding GPS, Principles and Applications, Artech House, Norwood MA, 1996.

8. Misra, P., and Enge, P., Global Positioning System, Signals, Measurements and Performance, Ganga-Jamuna Press, Lincoln, MA, 2001.

KEYWORDS: Global Positioning System (GPS), Inertial Navigation System (INS), Ultra Tightly Coupled GPS/INS, integrated navigation systems, Anti-Jam technology, ballistic missile defense, surface strike, missiles, guidance, navigation and control